CoNNeCT's Approach for the Development of Three Software Defined Radios for Space Application

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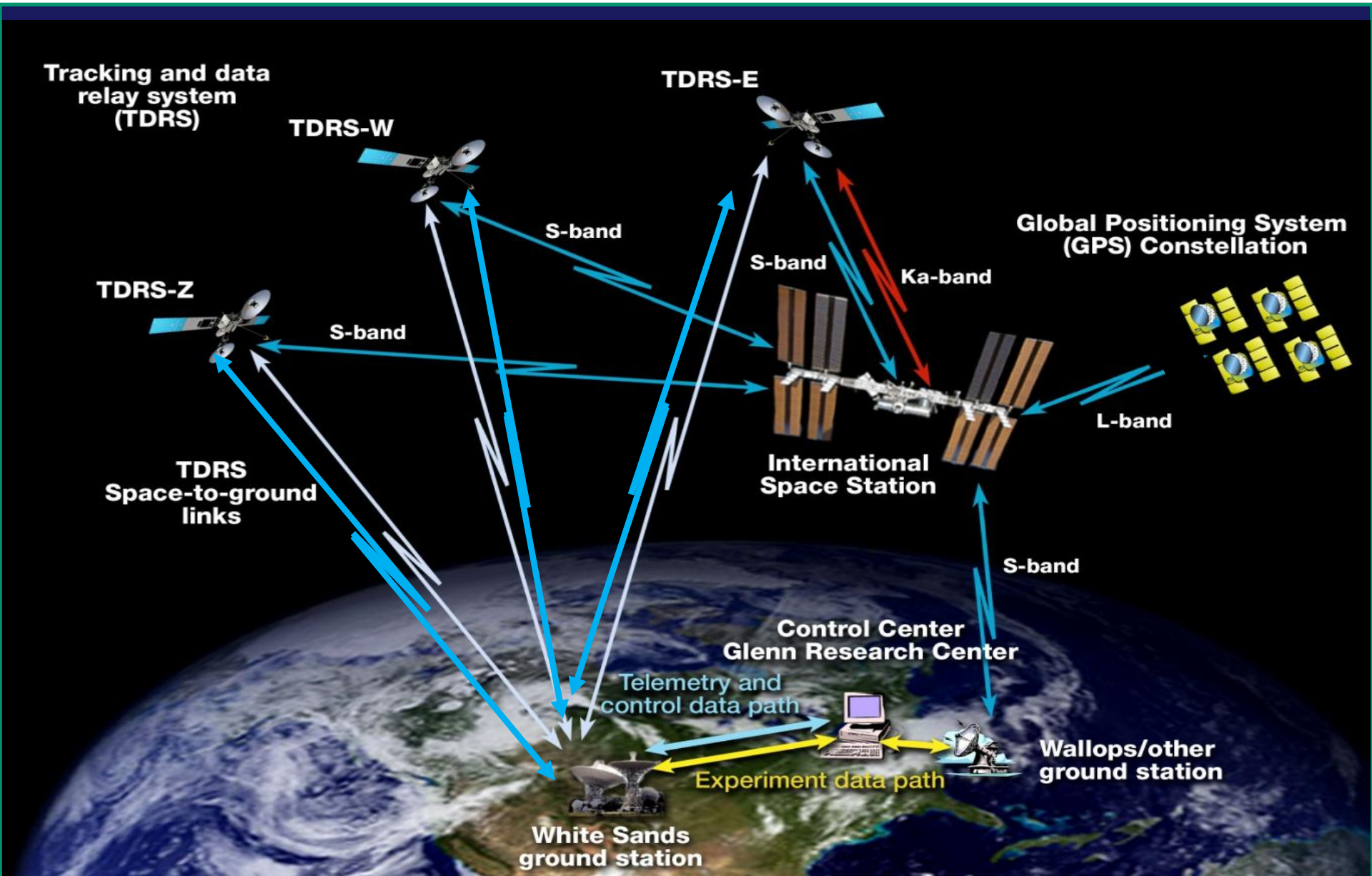
Scope / Purpose of Paper

- Describe Acquisition, System Engineering, and Development approach for CoNNeCT's 3 Software Defined Radios (SDRs)

- Provide Lessons Learned

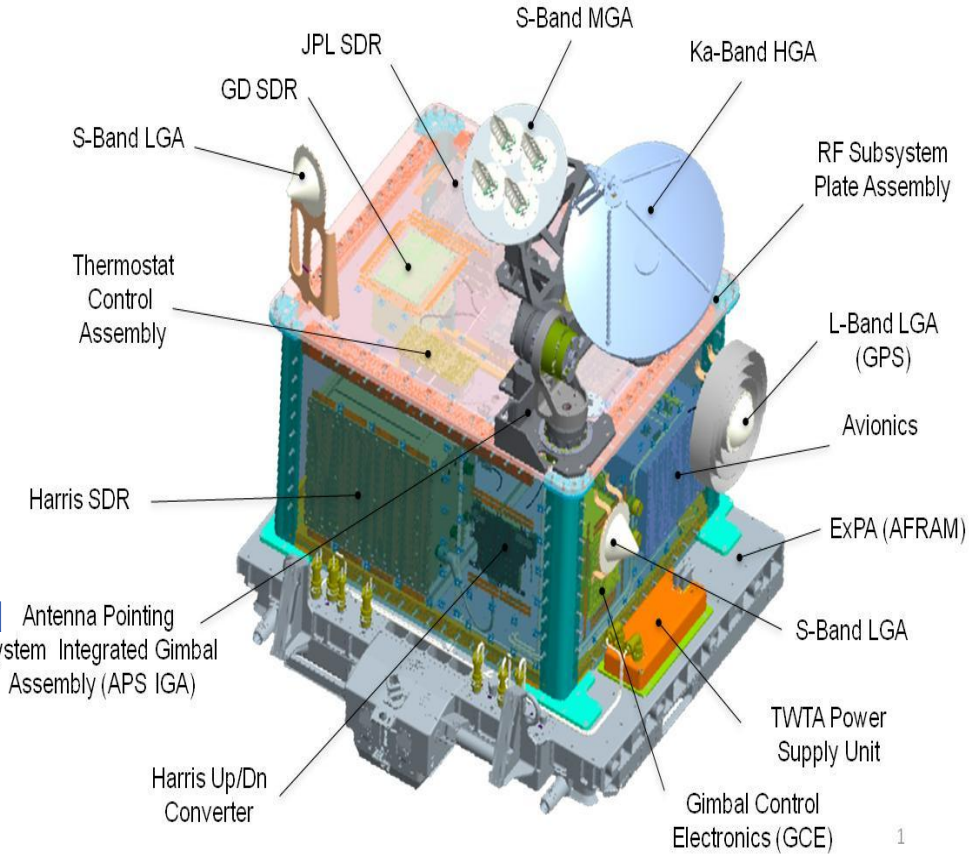
Procuring Software Defined Radios for Space Requires a Unique Development Approach

SCAN Testbed System Architecture



Flight System Overview

- Communication System
  - SDRs
    - 2 S-band SDRs (1 with GPS)
    - 1 Ka-band SDR
  - RF
    - Ka-band TWTA
    - S-band switch network
  - Antennas
    - 2 - low gain S-band antennas
    - 1 - L-band GPS antenna
    - Medium gain S-band and Ka-band antenna on antenna pointing subsystem.
  - Antenna pointing system.
    - Two gimbals
    - Control electronics
- Flight Computer/Avionics
- Flight enclosure provides for thermal control/radiator surface.



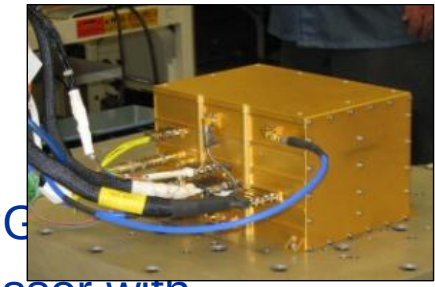
Total mass ~746 lb

CoNNeCT SDR Platform Descriptions

Harris

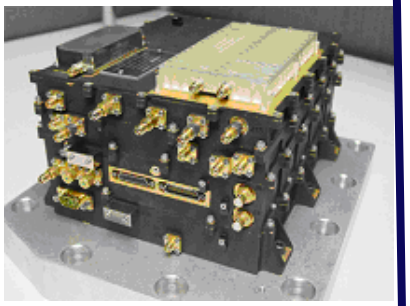
- TDRSS Ka-band (Tx & Rx
- 4 - Virtex IV FPGAs
- 1 - GFLOP DSP
- AiTech 950 with VxWorks RTOS
- Scrubbing ASIC

General Dynamics



- TDRSS S-band (Tx & Rx)
- 1 - Virtex II QPro FPG
- ColdFire microprocessor with VxWorks RTOS
- CRAM (Chalcogenide RAM) Memory (4 Mb)

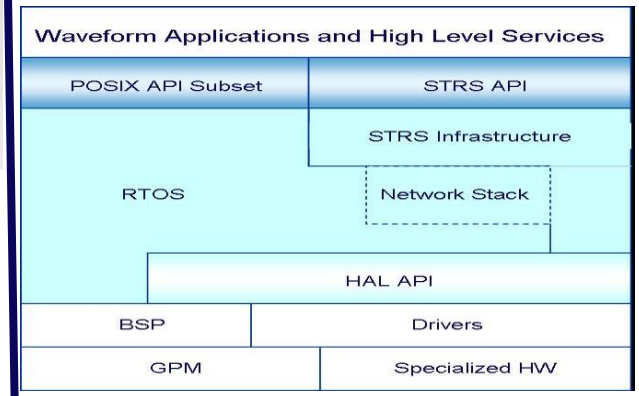
JPL/L-3 CE



- L-band receive (GPS)
- TDRSS S-band
- 2- Virtex II FPGA (3 M gates each)
- Actel RTAX 2000
- Actel AT697 with SPARC V8 Processor using RTEMs OS

STRS

- Advance STRS/SDR Platforms to TRL-7
- Single standard on SDR and WF



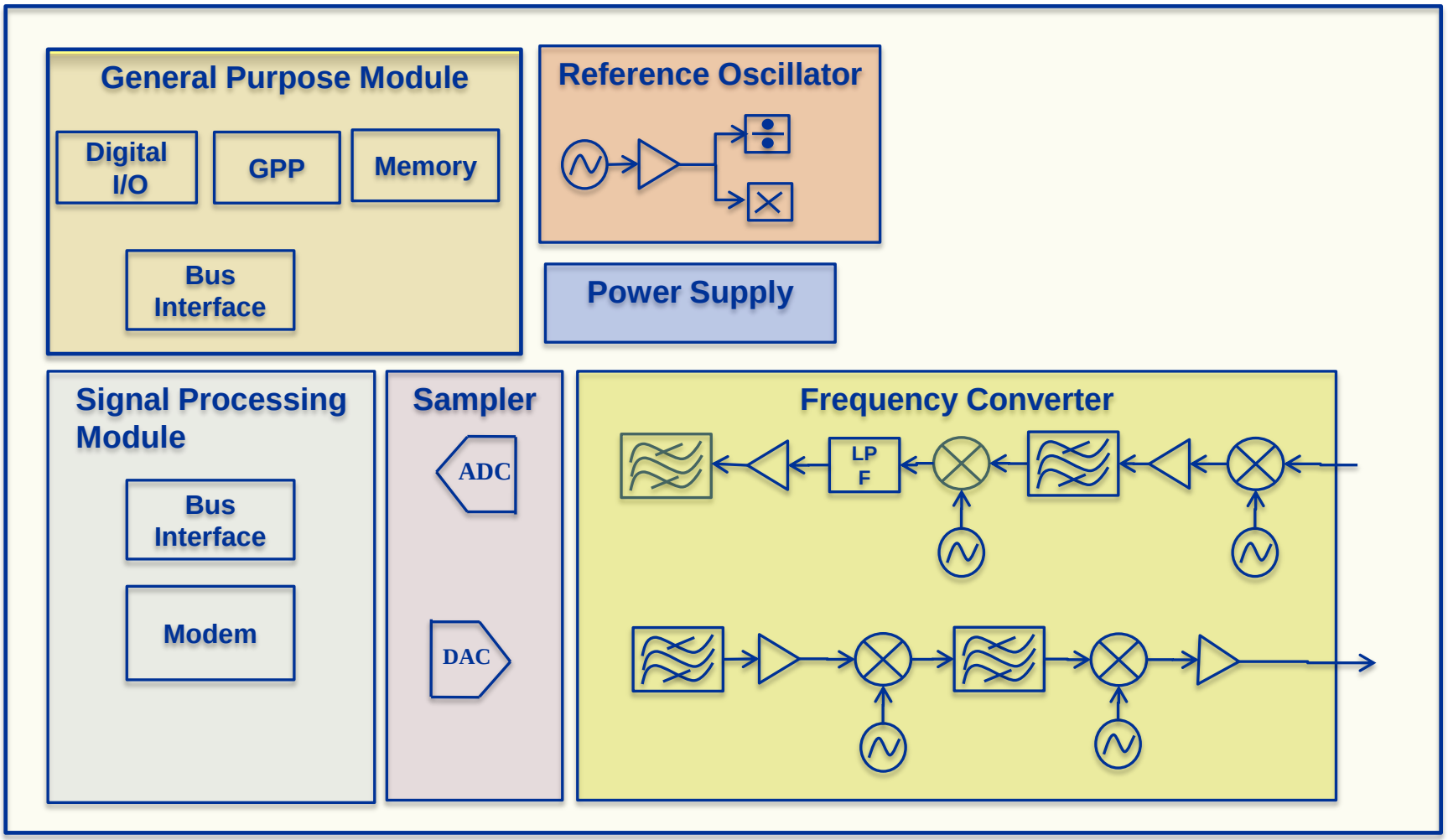
- Compliance verified w/
  - -tools
  - -inspection
  - -observation

All SDRs will be launched with TDRSS-compliant waveforms.

SDR Procurement Approach and Schedule

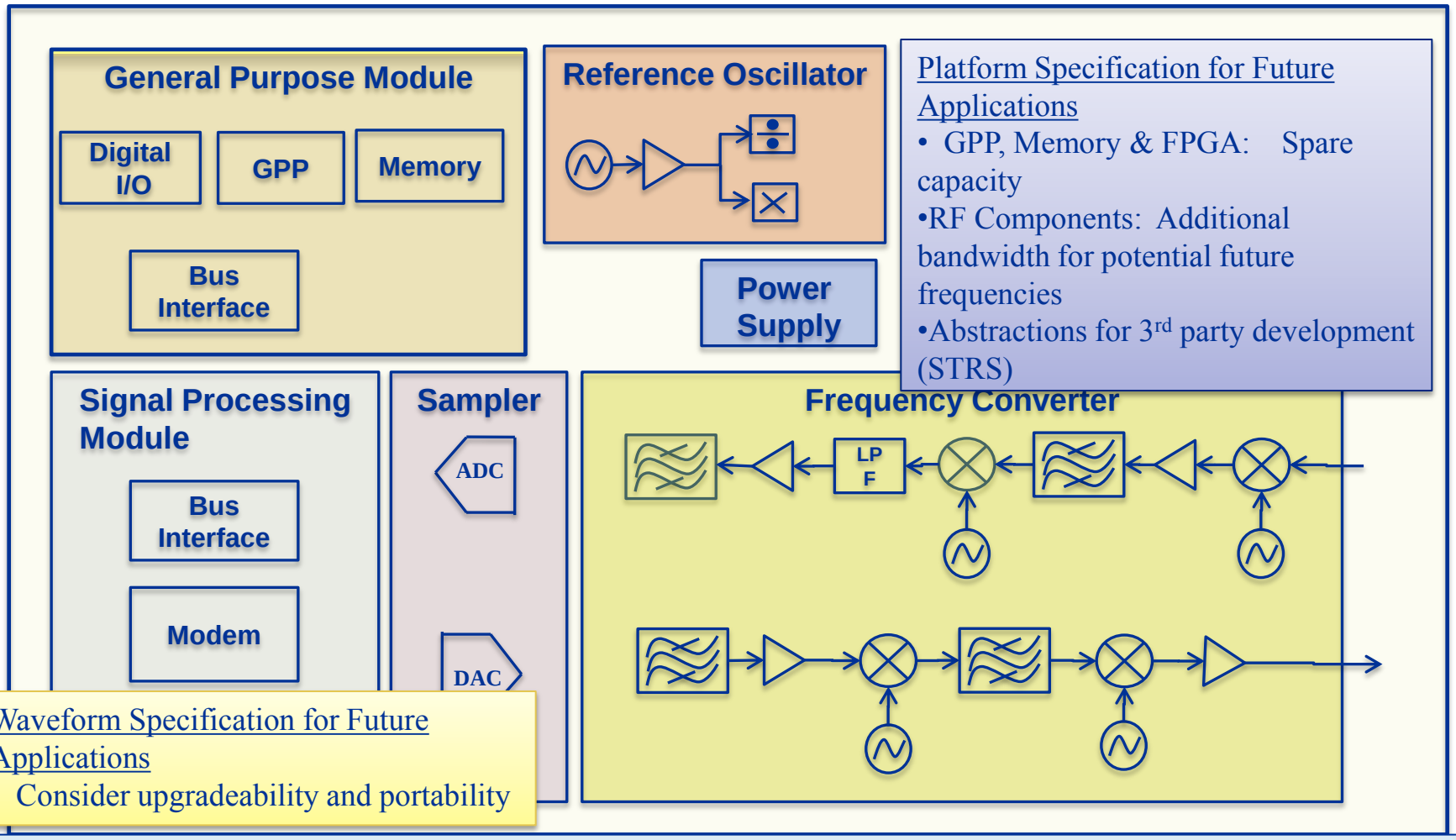
- Harris and GD SDRs purchased using competitive NASA Research Announcement which led to cost-sharing Cooperative Agreements
- From initial requirement development to subsystem delivery: approximately 2 years
- S-band requirements derived from similar TDRSS Transponder specifications with additional considerations for reconfigurability and upgradeability.
- Limited Ka-band TDRSS User specifications available.
  - Breadboard development prior to specifying flight system would have been preferred.

Specifications for Fixed Transceiver



Focused on functionality, with components specified by vendor. Single vendor. Future applications and upgrades not considered

Specifications for a Reconfigurable Transceiver



SDR Specification Challenges: Separate platform and application specification and vendor possible. Likely to exceed current mission needs. Must consider future applications and upgrades. Platform must be characterized.

Harris Development and Test Learned

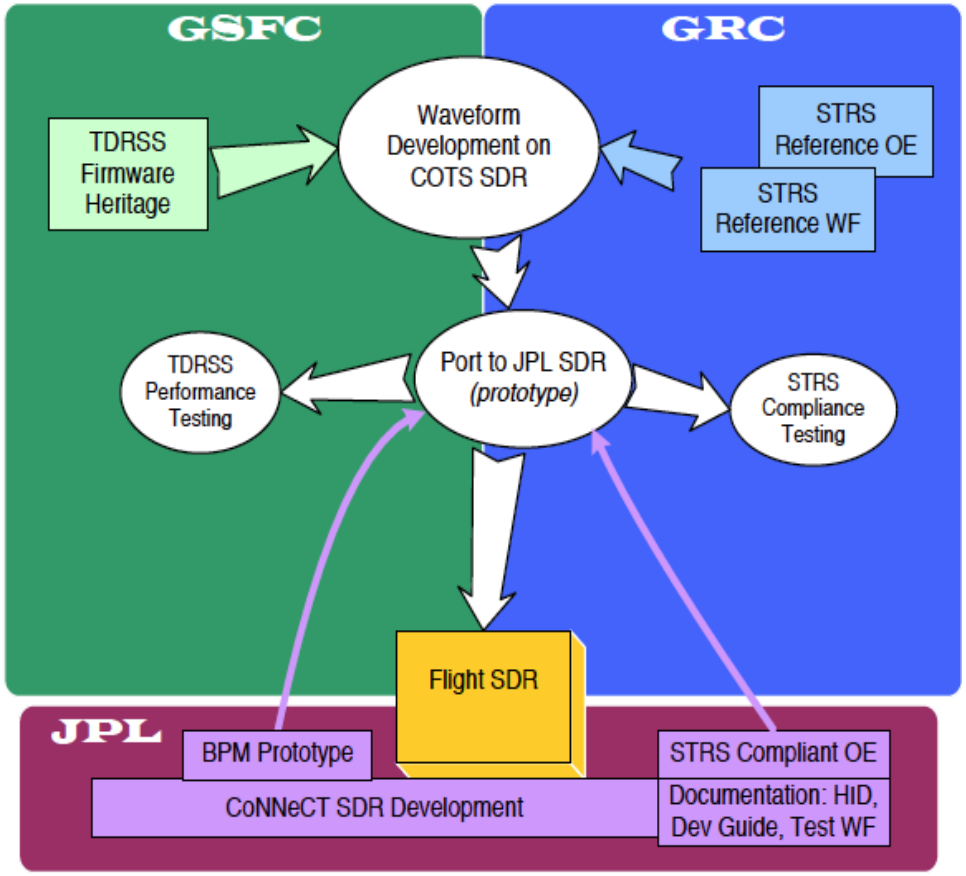
- Functional requirements provided by NASA (with Harris involvement) with additional “upgrade” guidance.
- Harris team decomposed into platform and waveform specifications (at implementation level).
- Harris platform NOT optimized for SWaP (1st gen).
- Customizable control/telemetry interfaced developed
  - Reduced risk of relying on documentation to define interfaces
  - Useful for post-shipment test and bench-top testing
- Delivered documentation set not useful for future waveform developers without significant work.
- Additional platform characterization preferred
  - Receiver gain control; output power response; thermal calibration; timing knowledge

General Dynamics Development and Test Learned

- Single function requirements written to reduce test time (data rate, implementation loss) but additional information and control still required.
- Interface testing with high fidelity test setup critical
- Testing needs to verify operation of all features and operations
  - SEU detection algorithm not working was discovered late in system testing.
  - Too late to make a fix, logic in non-reprogammable device
  - Telemetry value in test interface only

JPL Development and Test Learned

- JPL SDR development – parallel, multi-entity development approach for TDRSS Waveform



JPL SDR Development and Test Learned

- Platform requirements must contain requirements to characterize the the hardware to support future waveforms.
- Power and thermal allocation for future waveforms – worse case likely over conservative
- Required platform services
  - Add services needed by most/all waveforms to OE (e.g. drive level limitation, data interface)
- Parallel development requires additional schedule and resource considerations
  - Information exchange
  - Test approach
  - Potential variability between prototypes

General SDR Development Lessons Learned

- Identify early which SDR capability beyond mission requirements to include in requirements set
- Platform “test waveform” needed for vendor test and system environmental tests
- Additional documentation to support future waveform development must be reviewed carefully
- Breadboards/Engineering Models critical for schedule savings and diagnosing issues in parallel with system testing @ highest fidelity affordable, especially reprogrammable components
- Require BERT functionality as platform service
- Information in Configuration file (not hardcoded) for flexibility

SDR Development Conclusions

- Challenge: Balance “ilities” (flexibility, upgradeability, etc.) offered by SDRs with SWaP, resources, and schedule
- Spend systems engineering time to separate platform and waveform aspects
  - Provide both platform and waveform requirements
  - Balance mission requirements with potential SDR reprogrammability capability
  - Understand platform performance for future waveform developers
- Good documentation set required

Call for Experiment Proposals

- After Commissioning is complete (Fall 2012), the testbed will be available for experiments
- Announcement of Opportunity (AO) call in mid 2012 for external

  http://spaceflightsystems.grc.nasa.gov/SpaceOps/CoNNeCT/Candidate/

  – The call will go to NASA, industry, other government agencies, and academic partners

  – AO experiments selected will complement experiments already selected from internal to NASA and through the SBIR process

- Goal is to develop a consistent and coordinated utilization of CoNNeCT / SCAN Testbed for the benefit of the Space Communication and Navigation (SCaN) Program, and NASA

http://www.fedbizopps.gov/